

A Case Study on the Syntactic Complexity of Second Language Writing under Dynamic Systems Theory

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Abstract: This study combines Dynamic Systems Theory and case study methods to conduct an in-depth analysis of the syntactic complexity of second language writing. Forty-eight English writing samples from six non-English major college students at Software Engineering Institute of Guangzhou were regularly collected through the Pigai website. According to the description of the six indicators of syntactic complexity in L2SCA, SPSS statistical software was used to conduct quantitative analysis and time series analysis, the dynamic changing patterns of syntactic complexity in writing samples was depicted and combined with regular retrospective interviews. This study reveals that (1) the index shows a dynamic and systematic change trend over time, manifesting as volatility, nonlinearity and non-uniformity, which is in line with the Dynamic Systems Theory on second language acquisition development and changes prediction. (2) There are individual differences in the change patterns and speeds of syntactic complexity indicators among case learners, which may be related to factors such as learners' cognitive style, learning motivation and strategies. This study provides empirical research evidence and practical guidance for related research on the syntactic complexity of second language writing.

Keywords: Dynamic Systems Theory; Second Language Writing; Syntactic Complexity; Case Study

1. Introduction

Writing is an essential skill for second language learners. Second language writing develops complexity and dynamics, among which syntactic complexity is an important indicator. Dynamic Systems Theory provides a new perspective for understanding the development

of syntactic complexity in L2 writing.

2. Literature Review

From the perspective of Dynamic Systems Theory (DST), the current research status of syntactic complexity in second language writing is diversified, dynamic and empirical. The following is an overview of the current state of research:

2.1 Change of Research Perspective

Different from traditional static analysis, Dynamic Systems Theory focuses on the dynamic change process of syntactic complexity and emphasizes that learners' second language acquisition performance at different points in time is a system that is continuously adjusted and developed. This shift allows researchers to gain a deeper understanding of the essence of syntactic complexity in L2 writing. For example, Liu "discussed the characteristics that appear in the second language acquisition process, including sensitivity to the initial state, nonlinear development, complex dynamics, and self-organizing adaptability." [1] Ren "views the development of Chinese learners' second language writing ability as a complex dynamic system with characteristics and principles such as multiple time scales, high nonlinearity, multiple feedbacks, wide openness, spontaneity, and unpredictability." [2] Zhu pointed out that "indicators all have the development characteristics of variability, interaction, non-linearity and unpredictability, showing support, competition, fluctuation and high degree of coordination, and there are individual differences." [3]

2.2 Innovation in Research Methods

Under the guidance of Dynamic Systems Theory, researchers have used a variety of methods to explore the current situation of syntactic complexity in second language writing, mainly including: by collecting and analyzing

learners' writing samples at different time points in order to reveal the syntactic complexity index showing a characteristics of volatility, non-linearity and non-uniformity; or by constructing a network structure of syntactic complexity to illustrate the interrelationship between sentence length, sentence pattern diversity and other indicators; or by tracking the syntactic complexity of individual learners' writing over a long period of time aiming to explore individual differences and their influencing factors. For example, Ma "used type configuration as the unit of measurement to construct a syntactic complexity measurement system covering the three dimensions of quantity, length, and proportion, with a total of 6 types of configuration measurement indicators. By exploring the ability of the six indicators to reflect differences between groups, he made use of a preliminary verification of the possibility of using the pattern configuration index as a developmental index to measure the development of second language learners' syntactic complexity." [4] Zhao and Wang "used the L2 Syntactic Complexity Analyzer (L2SCA) to analyze the syntactic complexity of English compositions written by students in junior high schools, high schools, and academic universities." [5] Zheng and Li "used two variability calculation indicators to conduct regression analysis and cluster analysis on the writing data of 39 intermediate-level English learners in one year." [6]

3. Theoretical Framework

3.1 Dynamic Systems Theory

Larsen-Freeman proposed the limitations of traditional second language research methods in 1997 [7], and introduced Dynamic Systems Theory into second language acquisition research for the first time [8]. He finds that language learning is not linear, and the process is full of fluctuations of peaks and troughs, progress and regression, and its connotative characteristics are as follows: (1) **Dynamicity:** Dynamic Systems Theory emphasizes that the second language acquisition process is a dynamic process that is constantly changing, rather than a static or fixed state. (2) **Systematicity:** Dynamic Systems Theory regards the second language acquisition process as an overall system. This system is affected by internal and external factors, and there are also

differences in the ways of internal and external interactions. Dynamic Systems Theory regards the second language acquisition process as a complex, volatile, and dynamic process, and the various factors of language acquisition interact and influence each other, which is more in line with the actual process of second language acquisition.

3.2 Syntactic Complexity

Second language writing is an important measure of second language acquisition, and syntactic complexity is often used as an important dimension to measure second language writing. According to Halliday (1985), the definition of syntactic complexity for second language learners includes morphological complexity, lexical complexity, syntactic complexity and phonetic complexity [9]. Syntactic complexity focuses on the diversity and complexity of sentence structures, including clauses, T-units, noun phrases, verb phrases, and the combinatorial relationships between them. The different arrangements and combinations of these elements constitute the complexity of the sentence, thus reflecting the language acquisition ability and level of the writer. According to the syntactic complexity analysis tool proposed by L2 Syntactic Complexity Analyzer (L2SCA), syntactic complexity includes 14 indicators in 5 categories.[10] Theoretically, the longer the language unit output by the writer, the higher the usage density of the following specific syntactic structures exhibited by the writer; the more mature the syntactic features of the discourse, and the higher the syntactic complexity.

4. Research Design and Results

4.1 Research Questions

Under the guidance of Dynamic Systems Theory and syntactic complexity, this study intends to answer the following questions:

- (1) What are the dynamic development characteristics of syntactic complexity in second language writing? Does it conform to the description of Dynamic Systems Theory?
- (2) What are the individual characteristics of the diachronic development of syntactic complexity in second language writing? How does it relate to the learners' writing proficiency?
- (3) What intra-individual factors are involved in

changes in syntactic complexity in second language writing?

4.2 Experimental Objects

This study takes 6 students from the College English Teaching Class of Business Administration Major at Software Engineering Institute of Guangzhou as participants. Among them, 4 are girls and 2 are boys, with an average age of 19.67 years old, native speakers of Chinese, and an average of 10.76 years of English learning. According to the CET-4 examination scores, they were divided into high-level group (average score 516.5), middle-level group (average score 485.5), and low-level group (average score 436.5). Through SPSS significance testing, there are significant

differences between the three levels of groups ($P=0.000$), that is, the differences between multiple groups of data are not caused by random errors, but real. The study collected 8 writing tasks they completed in the same semester, with a total of 48 writing samples, each of 300-700 words, and a total of 25,484 words. All writing tasks were taught by the same teacher, and students were required to complete them within 90 minutes in an argumentative style and submit them to the Pigi website for review and storage. See Table 1 below for specific writing topics. This study also used retrospective interviews to allow students to review and describe their personal learning experiences and perceptions. See Table 2 below for specific interview questions.

Table 1. Writing Task Design

Type	Task
1.Opinion statement type:	(1)The Importance of College Education Write an essay expressing your opinion on the importance of college education. You may discuss the benefits of a college degree, the skills and knowledge gained, and the impact on future career opportunities.
	(2)The Value of Traveling Write an essay discussing the value of traveling. You may explore the benefits of experiencing different cultures, broadening horizons, and personal growth.
2.Problem-solving type:	(3)Solving Traffic Congestion in Big Cities Write an essay proposing solutions to the problem of traffic congestion in big cities. You may discuss the causes of traffic congestion, the impact on daily life, and possible solutions such as public transportation, urban planning, and technology.
	(4)Addressing Climate Change Write an essay discussing possible solutions to the problem of climate change. You may explore the causes of climate change, the impact on the environment and human society, and potential solutions such as renewable energy, conservation efforts, and international cooperation.
3.Phenomenon analysis type:	(5)The Rise of Social Media Write an essay analyzing the rise of social media. You may discuss the reasons for its popularity, the impact on communication and relationships, and the potential negative consequences.
	(6)The Aging Population Write an essay analyzing the aging population phenomenon. You may discuss the causes of the aging population, the impact on healthcare systems, and the potential solutions to address the challenges.
4.Comparative analysis type:	(7)Online vs. Traditional Education Write an essay comparing online and traditional education. Discuss the differences in learning experiences, effectiveness, and accessibility between the two methods.
	(8)Urban vs. Rural Living Write an essay comparing urban and rural living. Analyze the differences in lifestyle, opportunities, and challenges faced by people living in urban and rural areas.

Table 2. Retrospective Interview Angles and Questions

Angles	Questions
1.Personal background and language learning experience:	(1)Please briefly introduce your educational background and second language learning experience.

Understand the participants' basic situation and language learning background	(2)What challenges have you encountered when learning a second language, and how did you overcome these challenges? (3)What do you think your second language writing level is, and what are your strengths and weaknesses?
2. Writing habits and strategies: Explore the participants' writing habits and strategies	(1)What fixed habits or processes do you have during writing? (2)What strategies have you adopted to improve syntactic complexity? (3)What do you think of language errors encountered in the writing process, and how do you usually deal with them?
3. Understanding and application of Dynamic Systems Theory: Assess the participants' understanding of Dynamic Systems Theory and its application in writing	(1)How do you understand the role of Dynamic Systems Theory in second language writing? (2)How do you think Dynamic Systems Theory can be of practical help to your writing? (3)During the writing process, did you consciously try to apply Dynamic Systems Theory?
4. Experimental feelings and feedback: Collect participants' feelings and suggestions about the experiment	(1)How did you feel about participating in this writing experiment? (2)Which aspects of the experiment do you think will help you improve your writing skills? (3)Do you have any suggestions or feedback on the design and implementation of the experiment?
5. Future learning and development plans: Understand the participants' views on future learning and development plans	(1)How do you plan to continue to improve your second language writing skills in the future? (2)What role do you think Dynamic Systems Theory will play in your study plan? (3)What expectations or concerns do you have about participating in similar research?

4.3 Annotation and Analysis Tools

Combined with the 14 indicators in 5 categories proposed by L2SCA, this study annotates and

analyzes the collected writing samples based on the following 4 dimensions and 6 indicators. See the Table 3 below for detailed dimension analysis and indicator content.

Table 3. Four Dimensions and Six Indicators in L2SCA

Dimension	Index	Label	Example	Calculation method
Unit Length	mean length of clause	MLC	“Although it was raining, we went to the park.” “We played soccer until it got dark.” “Then, we had a picnic.”	Clause length 4, 5, 7, 1, 4 Number of clauses 5 Average clause length 4.2
	mean length of sentence	MLS	“Although it was raining, we went to the park.” “We played soccer until it got dark.” “Then, we had a picnic.”	Sentence length 9, 7, 5 Number of sentences 3 Average sentence length 7
	mean length of T-unit	MLT	“Although it was raining, we went to the park.” “We played soccer until it got dark.” “Then, we had a picnic.”	Total number of words 4+5+9, 7, 1+4+5 Number of T-unit 3 Average length of T-unit is 11.67
Unit Density	clause per T-unit	C/T	“It is important to pick up a foreign language because you need to understand a new culture and need to do intercultural communication.”	Number of clauses 3 Number of T-unit 3 Clause per T-unit ratio 1
Parallelism	coordinate phrases per T-unit	CP/T	“The cat slept on the mat, but the dog played in the yard. They enjoyed that day.”	Number of parallel phrases 1 Number of T-unit 2 Coordinating phrase per T-unit ratio 0.5

Phrase Structure	complex nominals per clause	CN/C	“Despite the company’s impressive growth, the new product launch was a failure. It was mainly due to poor market research and lack of customer interest.”	Number of complex noun phrases 4 Number of clauses 2 Complex nominals per clause ratio 2
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4.4 Results and Discussion

4.4.1 Indicators and values of unit length (Taking MLC, MLS, MLT as examples)

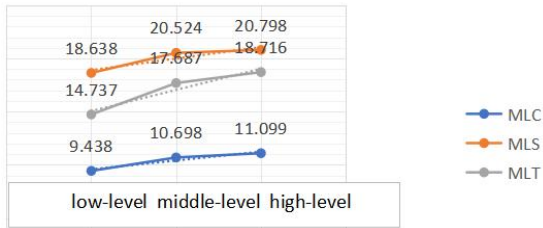


Figure 1. MLC, MLS, MLT Averages and Trend Lines

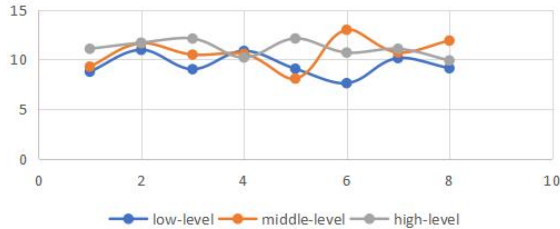


Figure 2. MLC Numerical Change Trend Chart

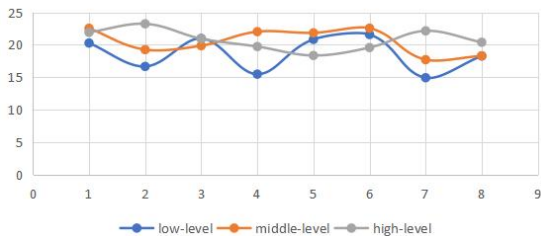


Figure 3. MLS Numerical Change Trend Chart

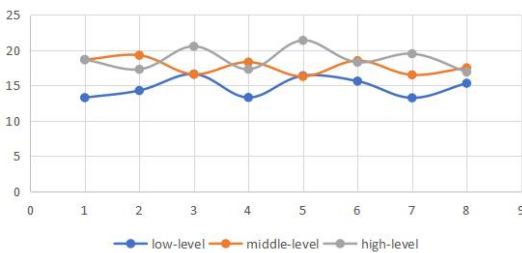


Figure 4. MLT Numerical Change Trend Chart

The results based on Figure 1 shows that all three indicators increase numerically from the low-level group to the high-level group, but the increases from the middle-level group to the high-level group (0.401, 0.274, 1.029) are significantly lower than the increases from the low-level group to the middle-level group

(1.260, 1.886, 2.950), that is, the unit length only increases significantly from the low-level group to the middle-level group. It can be seen that the unit length gradually increases along with the improvement of writing frequency and level, but after entering the middle-level group, the increase of the three indicators slows down. The values of the three indicators increase among each level group, but the growth margin is different. The values of the low-level group fluctuate greatly, followed by the middle-level group, and the values of the high-level group are relatively stable. Specifically, the Figure 2, 3, 4 reveal that the average values of MLC, MLS, and MLT in the low-level group are 9.44, 18.64, and 14.74 respectively, and the standard deviations are 1.06, 2.49, and 1.32 respectively; the middle-level group are 10.70, 20.52, and 17.69 respectively, and the standard deviations are 1.44, 1.84, 1.07; the high-level group is 11.10, 20.80, 18.72 respectively, and the standard deviation is 0.77, 1.49, 1.52 respectively. This shows that students in the high-level group are more stable in terms of unit length indicators, while students in the middle- and low-level groups may be affected by more factors, resulting in larger numerical fluctuations.

Combined with the interview records from participants, in order to obtain higher writing scores on the Pigai website, students gradually increased their awareness of using long and complex sentence structures by adding clauses or non-finite verb forms. However, they were limited by their second language writing proficiency, because the growth rate of the three indicators slowed down from the middle- to the high-level group. As the number of writing tasks increases, it is foreseeable that the above indicators and values will continue to fluctuate and grow, on top of that they are no longer limited to the simple subject-verb-object structure, but are able to use clauses and complex structures. However, since the calculation method of the three indicators involves the number of sentences, clauses, and words, there may be a surge or sharp decline in the short term, causing the trend chart to show fluctuating development.

4.4.2 Indicators and values of unit density (Taking C/T as an example)

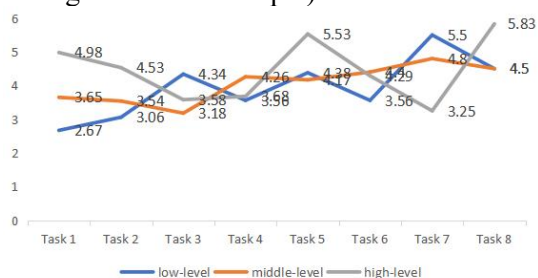


Figure 5. C/T Numerical Change Trend Chart

As shown in the Figure 5 above, in the first writing task, the C/T value of the high-level group exceeds that of the middle- and low-level groups. From the second to the third writing task, the C/T values of the middle- and high-level groups decrease, but the low-level group gradually increases and even surpasses the values of the middle- and high-level groups. In the fourth writing task, the values of the high- and low-level groups remain the same or drop until they are close to each other, but the values of the middle-level group rise to the highest level at that time. The fifth and seventh writing tasks experience the highest values in the entire process for the three level groups respectively. In the eighth writing task, the C/T value of the low-level group is close to that of the middle-level group. Throughout the process, the three groups of C/T values show a significant fluctuation trend, accompanied by multiple increases and decreases during the period, and the three groups of values fail to be consistent or close to the peak point apparently. The C/T values of the three different groups all develop in a roundabout and fluctuating way. Each group is unable to show a straight upward or downward trend. This can prove that the nonlinear development of second language writing ability is in line with the dynamic characteristics of the Dynamic Systems Theory, that is, the second language writing ability develops in a fluctuating way. The development of second language writing ability is not a straight line, but a tortuous path, with fluctuations and repetitions. Learners may experience periods of plateauing, regression, and rapid progress in the writing process.

Combined with the interview records from participants, the reasons for the above-mentioned fluctuations include that learners may not fully master the necessary grammatical

rules, especially regarding the construction and usage of clauses; limited vocabulary may limit learners' ability to construct diverse sentence structures; learners may not be sensitive to the natural flow of sentences when formulating and expressing complex ideas.

4.4.3 Indicators and values of parallelism (Taking CP/T as an example)

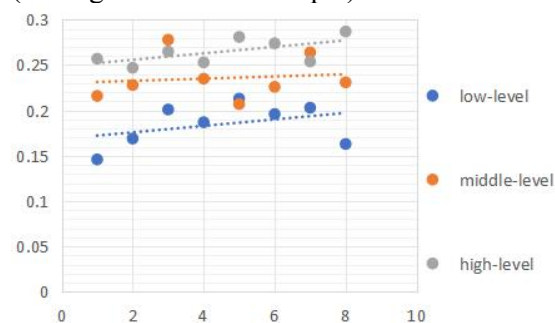


Figure 6. CP/T Numerical Change Trend Chart

Table 4. Average Values of CP/T

Label	Low-level average	Middle-level average	High-level average
CP/T	0.185	0.236	0.265

The results in Figure 6 and Table 4 show that despite CP/T can distinguish learners of different levels, this distinction does not change significantly as the number of tasks increases. This suggests that as writing proficiency improves, the frequency and methods in which students use coordinating phrases differ, with the high-level group using coordinating phrases more frequently or more effectively. Although CP/T can differentiate learners of different levels, its changes are not significant over time, which is consistent with the nonlinear prediction of language development from Dynamic Systems Theory.

Dynamic Systems Theory suggests that language development is non-linear, meaning that the syntactic complexity of L2 writing may develop at a non-uniform rate. Changes in CP/T may not be a simple, straight-line progression, but may show fluctuations, jumps or plateaus. Language development may tend towards certain stable states that result from the syntactic usage habits formed by learners. In addition, Dynamic Systems Theory also emphasizes the dynamic balance between stability and change of the overall system. Even if the overall writing level is relatively stable, learners may still change in the specific ways of using parallel

phrases.

Interview records of participants show that there are differences in the understanding and use of parallel structures among different students, which reflects differences in their cognitive processing abilities in processing complex syntactic structures. Students who have a positive attitude towards English writing and have a high motivation are likely to make more significant improvements.

4.4.4 Indicators and Values of Phrase Structure (Taking CN/C as an Example)

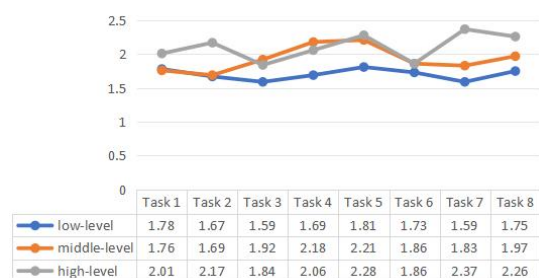


Figure 7. CN/C Numerical Change Trend Chart

Table 5 Average Values of CN/C

Label	Low-level average	Middle-level average	High-level average
CN/C	1.701	1.928	2.106

The results in Figure 7 and Table 5 show that CN/C can significantly distinguish different levels of writing complexity, but cannot distinguish the writing ability of students in the middle- and high-level groups (the average difference between the two is less than 0.18). The low- and middle-level groups have lower CN/C averages, most of which are below 2.0, indicating that these learners use less complex noun phrases in their writing, or start to use more complex noun phrases. However, the average CN/C value of the high-level group is higher, and it is below 2.0 only once, indicating that these learners can use complex noun phrases more frequently. This indicates that as writing proficiency improves, students' use of complex noun phrases increases. All three groups decline rapidly or slowly after the highest value, which may mean that second language writers have reached a certain similar level or critical point in the use of complex noun phrases. At this stage, further improvement of CN/C values may become more difficult, so the growth trend gradually slows down or even declines.

Dynamic Systems Theory points out that the

development of language acquisition and writing skills may show a non-linear curve, including periods of rapid progress, stable periods and slow progress. The CN/C value experiences fluctuations, reflecting learners' gradual adaptation to new syntactic structures. In addition, Dynamic Systems Theory also emphasizes systemicity, that is, the interdependence and interaction between components within the system.

Combined with the interview records from participants, during the development of writing ability, there is a correlation between the CN/C indicator and other syntactic structures in writing, which is affected by factors such as the learners' background and experience. For example, students' different levels of grammar training may affect their use ability of complex noun phrases.

5. Conclusion

This study combines Dynamic Systems Theory and case study methods to conduct an in-depth analysis of the syntactic complexity of second language writing. A total of 48 English writing samples from 6 non-English major college students at Software Engineering Institute of Guangzhou were regularly collected through the Pigi website. Based on the 4 dimensions and 6 index requirements of syntactic complexity in L2SCA, SPSS statistical software was used to conduct quantitative analysis and time series analysis. Combined with periodic retrospective interviews, the dynamic changing patterns of syntactic complexity in case writing are depicted.

The research results show that students in different proficiency groups exhibit different initial levels and changing processes of syntactic complexity. This shows that learners gradually master the skills of syntactic complexity during the writing process and are able to adjust it according to their own level. In all writing tasks, the reference values of various syntactic complexity did not show a linear upward or downward trend, which is in line with the dynamic and systematic characteristics of Dynamic Systems Theory. This finding reveals the fluctuating, non-linear and non-uniform characteristics of the development of writing syntactic complexity, that is, learners may experience peaks, troughs, and continuous states during the writing process. This study is of great significance for

understanding the development of syntactic complexity in the second language writing process. It not only helps to understand learners' cognitive changes in the writing process, but also provides empirical basis for second language writing teaching. Teachers should recognize the differences in syntactic complexity among learners of different levels and provide personalized guidance based on students' characteristics. This means that teaching activities need to adapt to the needs of different students, and second language writing teaching should follow the Dynamic Systems Theory to reflect the dynamic change process of language learning. Teachers should track students' writing development over a long period of time instead of evaluating based on just one or a few writing tasks. This study also provides reference and inspiration for further theoretical exploration and research related with the syntactic complexity of second language writing.

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